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THE IMPORTANCE OF COMPLETENESS OF REVASCULARIZATION DURING LONG-TERM FOLLOW-UP AFTER CORONARY ARTERY OPERATIONS

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Completeness of revascularization after coronary artery bypass operation has been shown to improve short- and medium-term outcome. The purpose of this study was to assess the independent contribution of completeness of revascularization to long-term outcome. A total of 2057 patients with multivessel disease with complete revascularization and 803 with incomplete revascularization, mean age 57 ± 9 years, was studied. The patient groups were similar except for more prior myocardial infarctions, worse left ventricular function, and more three-vessel disease in the incomplete revascularization group. Complications of perioperative infarction and stroke were not different between those having complete versus incomplete revascularization. The hospital death rate for patients having complete revascularization during the period of study was 0.7% versus 1.5% for those having incomplete revascularization ($p = 0.06$). Length of hospital stay for the two groups of patients also was not different. At late follow-up (mean 11.7 years for complete and 10.8 years for incomplete) patients who had incomplete revascularization had a significantly higher prevalence of recurrent angina. Multivariate analysis demonstrated the strongest predictors of incomplete revascularization to be number of vessels diseased and left ventricular function (ejection fraction). The multivariate correlates of survival were older age, left ventricular dysfunction, and completeness of revascularization. Completeness of revascularization correlated with improved overall patient survival, as well as survival in patients with normal left ventricular function. Furthermore, the curves continued to separate over time, such that the difference was greater at 8 years than at 4 years, although by 12 years the curves started to converge. (J Thorac Cardiovasc Surg 1996;112:227-37)

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Since the inception of the coronary bypass operation, surgeons have believed, and they continue to believe, that completeness of the initial revascularization procedure is a prime prerequisite for success.[1, 2] With the proliferation of angioplasty in recent years, cardiologists have sometimes minimized the importance of such logic and have relied instead on frequent observation, multiple catheterizations, and repeated angioplasty as stenoses progress or symptoms reoccur. Because of this philosophical difference, it seemed important to perform a retrospective analysis of the clinical, angiographic, and operative characteristics that might affect completeness of revascularization during coronary bypass operations. In addition, an analysis was done to determine the correlates of complete revascularization, angina at follow-up, and survival to determine those factors thought to be important in achieving operative success and long-term satisfactory results.

Methods

The cases of all patients who underwent cardiac catheterization followed by first-time elective coronary artery bypass operation for multivessel coronary artery disease at Emory University Hospitals between January 1, 1978, and December 30, 1981, were analyzed from the Cardiac Data Registry. Follow-up was conducted by mail or telephone survey. In addition, data on all reoperative procedures or angioplasties were retrieved from the computer database. Patients who had associated complex cardiac procedures, such as valve replacement or aneurysm repair, were excluded. The total population of patients available for analysis was 2860. Follow-up during the postoperative period was 99% complete with a mean follow-up of 12 ± 4.4 years for survivors of the operation.

For the purpose of this study, complete revascularization was accomplished when at least one graft was placed distal to an approximately 50% diameter narrowing in each of the three major vascular systems in which arterial narrowing of this severity was noted. Thus if there were narrowings of approximately 50% in the circumflex and right coronary artery distributions, but not in the left anterior descending, then grafts would have to be placed in the circumflex and right coronary distributions distal to these arterial narrowings for there to be complete revascularization. It was not considered necessary to bypass all obstructed diagonal branches of the anterior descending or marginal branches of the circumflex coronary arteries for a classification of complete revascularization.

Statistical methods. All data were collected prospectively on standard forms and entered into a computerized database. All data were retrospectively analyzed with BMDP (BMDP Statistical Software, Inc., Los Angeles, Calif.) and Splus statistical software (MicroSoft, Inc., Seattle, Wash.). All data are expressed as mean plus or minus the standard deviation or as proportions. Survival was determined by Kaplan-Meier analysis with survival expressed as calculated probability plus or minus the

Table I. *Clinical and angiographic characteristics*

	*Incomplete (n = 803)**	*Complete (n = 2057)**	*p Value*
Age (yr)	57 ± 9	57 ± 9	0.84
Age ≥60 yr	330 (41%)	831 (40%)	0.75
Female	130 (16%)	326 (16%)	0.86
Diabetes	110 (16%) (*n* = 687)	236 (14%) (*n* = 1705)	0.19
System hypertension	318 (46%) (*n* = 694)	726 (42%) (*n* = 1740)	0.07
Class 3-4 angina	306 (56%) (*n* = 550)	667 (52%) (*n* = 1286)	0.15
Congestive heart failure	33 (5.2%) (*n* = 632)	83 (5.4%) (*n* = 1548)	0.98
Prior myocardial infarction	445 (63%) (*n* = 706)	961 (55%) (*n* = 1757)	0.0002

*Number except where otherwise specified.

Table II. *Angiographic characteristics*

	*Incomplete (n = 803)**	*Complete (n = 2057)**	*p Value*
Two-vessel disease	213 (27%)	977 (47%)	<0.0001
Three-vessel disease	492 (61%)	877 (43%)	<0.0001
Left main disease	98 (12%)	203 (10%)	0.08
LAD disease	743 (93%)	1865 (91%)	0.13
Maximum stenosis	81 ± 16 (*n* = 507)	81 ± 16 (*n* = 1355)	0.70
Total occlusion	444 (55%)	990 (48%)	0.0007
Ejection fraction	57 ± 15 (*n* = 732)	60 ± 14 (*n* = 1870)	<0.0001
Ejection fraction <50%	219 (30%) (*n* = 732)	374 (20%) (*n* = 1870)	<0.0001

LAD, Left anterior descending.

*Number except where otherwise specified.

Table III. *Procedural characteristics and outcome*

	*Incomplete (n = 803)**	*Complete (n = 2057)**	*p Value*
Grafts placed	2.6 ± 0.9	3.5 ± 0.9	<0.0001
≥3 Grafts placed	426 (53.1%)	1781 (86.6%)	<0.0001
Q wave myocardial infarction	23 (2.9%)	51 (2.5%)	0.65
Stroke	6 (0.8%)	20 (1%)	0.73
Death in hospital	12 (1.5%)	14 (0.7%)	0.06
Length of stay (days)	8.3 ± 6.1	8.2 ± 5.3	0.67
Angina during follow-up	315 (50%)	697 (42%)	0.0007
Time to follow-up (yr)	10.8 ± 4.7 (n = 630)	11.7 ± 4.3 (n = 1659)	<0.0001

*Number except where otherwise specified.

Table IV. *Correlates of incomplete revascularization*

	Univariate	*Multivariate*	
Variable	*p Value*	*p Value*	*Odds ratio (95% CI)*
Vessels diseased	<0.0001	<0.0001	2.15 (1.91-2.42)
Ejection fraction	<0.0001	<0.0001	0.986 (0.979-0.993)
Prior myocardial infarction	<0.0001	0.005	1.32 (1.08-1.61)
Hypertension	0.022	0.026	1.23 (1.02-1.48)

CI, Confidence interval.

Table V. *Correlates of death at long-term follow-up*

	Univariate		*Multivariate*		
Variable	χ^2	*p Value*	χ^2	*p Value*	*Hazard ratio (95% CI)*
Age	113	<0.0001	114	<0.0001	1.04 (1.03-1.05)
Ejection fraction	36	<0.0001	34	<0.0001	0.987 (0.982-0.991)
Incomplete revascularization	19	<0.0001	12	0.0005	1.26 (1.11-1.43)
Vessels diseased	19	<0.0001	6.0	0.015	1.12 (1.02-1.22)
Total occlusion	8.0	0.047	NS		

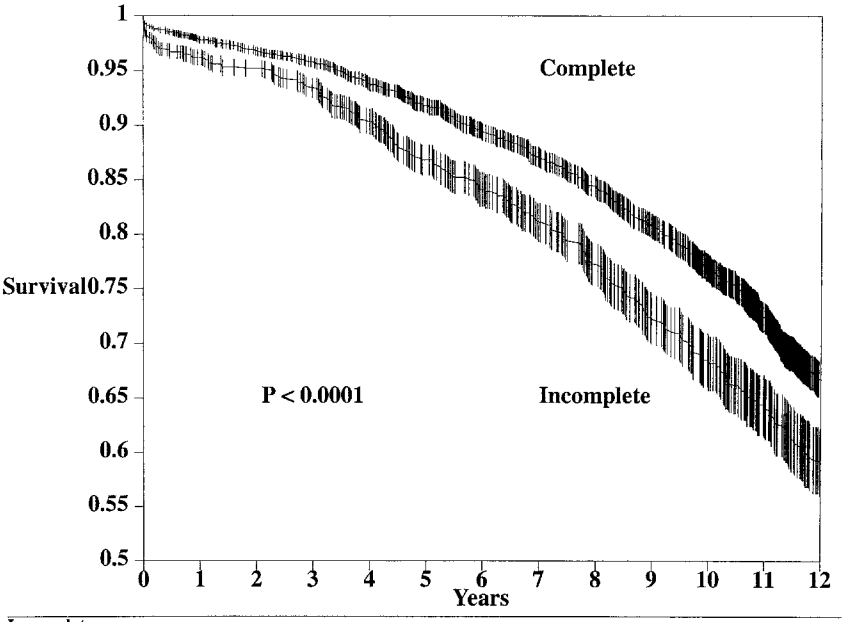
CI, Confidence interval; *NS,* not significant.

standard error of the mean. Differences in survival were determined by the Wilcoxon method. Correlates of survival were determined by Cox model analysis. Correlates of complete revascularization and of angina at follow-up were determined by stepwise logistic regression.

Operative technique. Standard cardiopulmonary bypass was done with hypothermia to a systemic nasopharyngeal temperature of 25° to 28° C. Myocardial preservation during this period was by oxygenated cold (4° to 8° C) crystalloid cardioplegic solution: potassium chloride solution (20 mEq/L) buffered to pH 7.40 and hyperkalemic-hyperosmolar solution of (concentrations in milliequivalents per liter) potassium 28, the bicarbonate radical 9.3, and sodium 95.7; 50% dextrose 3.2 ml; 15% mannitol 200 ml with sterile water to 1000 ml; pH 8.1; and osmolarity 415 mOsm at room temperature. Cardioplegic solution was administered at a volume of approximately 1000 ml initially and 250 ml every 20 minutes thereafter during which time the heart was immersed in cold saline solution. A single crossclamp was used for the performance of all distal anastomoses with a partial occlusion clamp used for the proximal anastomoses during rewarming of the patient. Coronary endarterectomy and internal thoracic artery grafting were infrequently used at this time.

Results

Perioperative clinical data. The total series included 803 patients with incomplete and 2057 patients with complete revascularization (Table I). The mean age of the two groups of patients was 57 ± 9 years, and 84% of patients in both groups were male. There was no difference in the distribution of ages, and 40% of patients with complete and 41% of those with incomplete revascularization were 60 years old or older. The high percentage of men and the young age of all patients was characteristic of patients having operation during the 4-year period from 1978 to 1981. There were slightly more patients with incomplete revascularization



Incomplete													
N Remaining	800	759	743	722	685	647	618	587	555	515	484	417	356
Survival	1	0.962	0.952	0.934	0.904	0.868	0.841	0.811	0.773	0.723	0.685	0.642	0.59
Deaths	0	30	38	52	75	102	122	144	171	207	234	263	296
Complete													
N Remaining	2032	1936	1904	1857	1805	1740	1672	1606	1549	1475	1386	1218	1023
Survival	1	0.978	0.968	0.958	0.938	0.918	0.894	0.87	0.844	0.808	0.77	0.724	0.667
Deaths	0	44	64	84	123	160	206	250	298	363	433	513	605

Fig. 1. Survival after complete and incomplete revascularization.

Table VI. *Correlates of angina at follow-up*

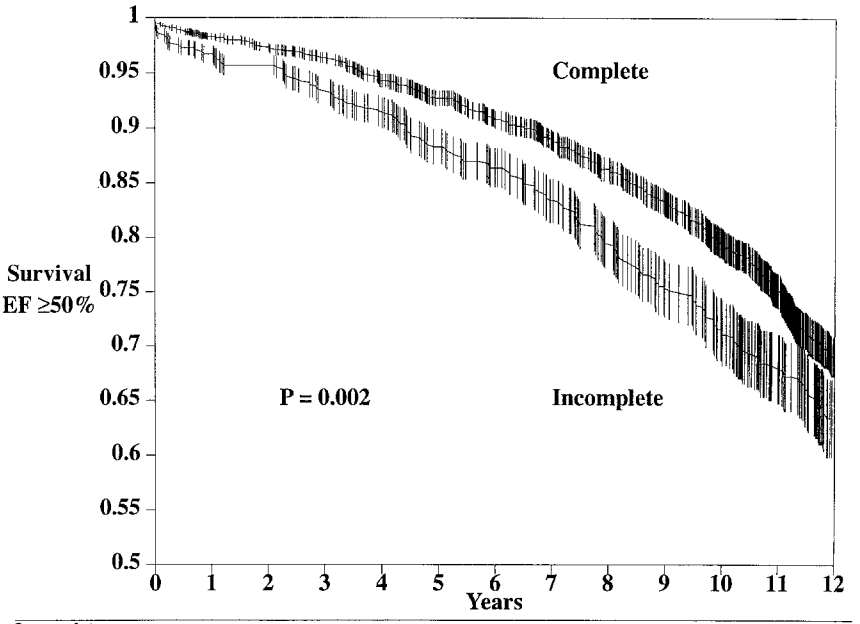
	Univariate	*Multivariate*	
Variable	*p Value*	*p Value*	*Odds ratio (95% CI)*
Age	<0.0001	<0.0001	0.97 (0.96-0.98)
Hypertension	<0.0001	<0.0001	1.46 (1.19-1.79)
Baseline angina class	<0.0001	0.0005	1.42 (1.17-1.73)
Female gender	0.0001	0.0006	1.59 (1.22-2.08)
Prior myocardial infarction	0.0005	0.0020	1.36 (1.12-1.65)
Diabetes	0.0004	0.005	1.57 (1.14-2.15)
Congestive heart failure class	0.019	0.090	1.51 (0.94-2.44)
Complete revascularization	0.029	NS	
Vessels diseased	0.18	NS	

CI, Confidence interval; *NS,* not significant.

who had hypertension. The only strong preoperative clinical difference between those patients receiving complete versus incomplete revascularization was the statistically higher prevalence of prior myocardial infarction in patients having incomplete revascularization (Table I).

Triple-vessel disease was significantly more common in patients having incomplete revascularization. Forty-three percent of patients with complete revascularization had triple-vessel disease compared with almost 61% of those with incomplete revascularization (Table II). As expected, preoperative left ventricular function was better in those who subsequently had complete revascularization (Table II). Whereas only 20% of those having complete revascularization had an ejection fraction less than 50%, almost one third of those having incomplete revascularization had a depressed ejection fraction.

Operative characteristics, in-hospital complications, and late follow-up. Table III depicts the difference in the frequency of graft utilization for



Incomplete													
N Remaining	511	490	479	462	447	422	407	389	367	344	324	284	244
Survival	1	0.967	0.957	0.935	0.916	0.883	0.864	0.834	0.795	0.753	0.716	0.679	0.634
Deaths	0	17	22	33	42	58	67	81	99	118	135	151	169
Complete													
N Remaining	1481	1420	1401	1369	1332	1290	1247	1205	1163	1117	1051	931	784
Survival	1	0.983	0.974	0.964	0.943	0.927	0.908	0.889	0.863	0.833	0.796	0.751	0.691
Deaths	0	25	38	52	82	104	130	156	191	232	281	339	410

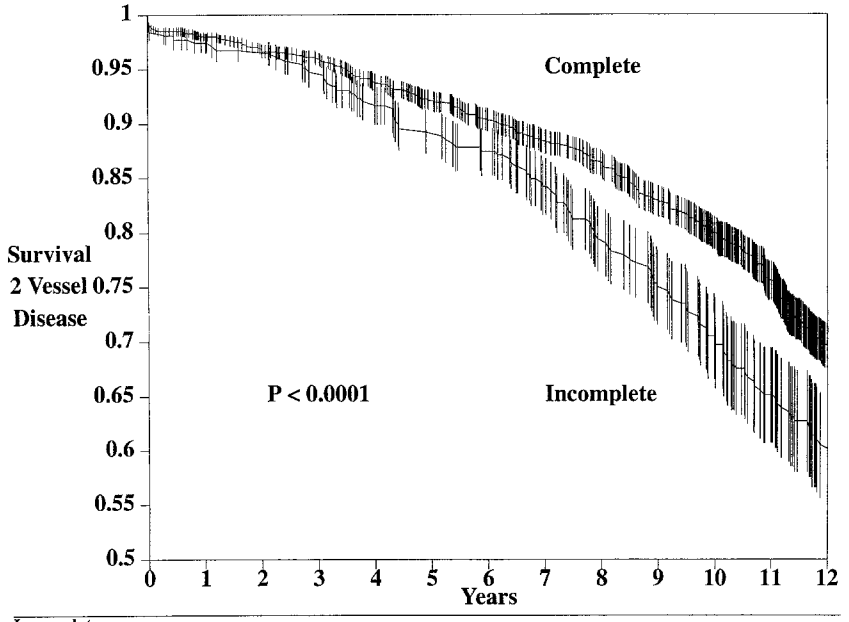
Fig. 2. Survival after complete and incomplete revascularization in patients with normal left ventricular function (ejection fraction [*EF*] approximately 50%).

the two groups of patients. Three or more grafts were placed in 86.6% of patients with complete revascularization versus only 52.5% of those in whom there was incomplete revascularization. Complications of perioperative infarction and stroke were not different between those having complete versus incomplete revascularization. The hospital death rate for patients having complete revascularization during this period of study was 0.7% versus 1.5% for those having incomplete revascularization ($p = 0.06$). Length of hospital stay for the two groups of patients also was not different.

After hospital discharge there was a large difference in the prevalence of angina at late follow-up (mean time 10.8 and 11.7 years for the incomplete and complete groups, respectively), with those having incomplete revascularization having a significantly higher prevalence of continuous recurrent angina (Table III).

Univariate correlates of incomplete revascularization are depicted in Table IV. Ability to achieve complete revascularization decreased as number of vessels diseased increased. Other strong correlates of ability to achieve complete revascularization were preserved left ventricular function and absence of prior infarction. The presence of hypertension was also correlated with incomplete revascularization. Multivariate analysis demonstrated the strongest predictors of incomplete revascularization to be increased number of vessels diseased and decreased left ventricular function (ejection fraction). The odds for complete revascularization were 2.15 times higher for three-vessel disease than for two-vessel disease. The odds for incomplete revascularization fell by about 1% for each 1% increase in ejection fraction. Perhaps surprisingly, diabetes was not a significant correlate of completeness of revascularization (Table IV).

Correlation of survival and postoperative angina. Univariate and multivariate predictors of survival after coronary bypass are shown in Table V. This analysis was confined to age plus angiographic variables. Older age and decreased left ventricular dysfunction demonstrated strong correlations with decreased long-term survival. Completeness of revascularization was also a strong univariate and multivariate predictor of survival. The extent of vessel disease was a somewhat weaker multivariate



Incomplete													
N Remaining	310	298	291	282	266	254	247	232	216	203	189	164	140
Survival	1	0.974	0.967	0.947	0.92	0.892	0.874	0.842	0.794	0.75	0.705	0.651	0.601
Deaths	0	8	10	16	24	32	37	46	59	71	83	97	109
Complete													
N Remaining	1164	1111	1090	1059	1029	993	962	929	900	861	818	719	606
Survival	1	0.98	0.969	0.96	0.938	0.921	0.903	0.884	0.864	0.83	0.8	0.756	0.697
Deaths	0	23	36	46	70	88	108	128	149	184	215	258	312

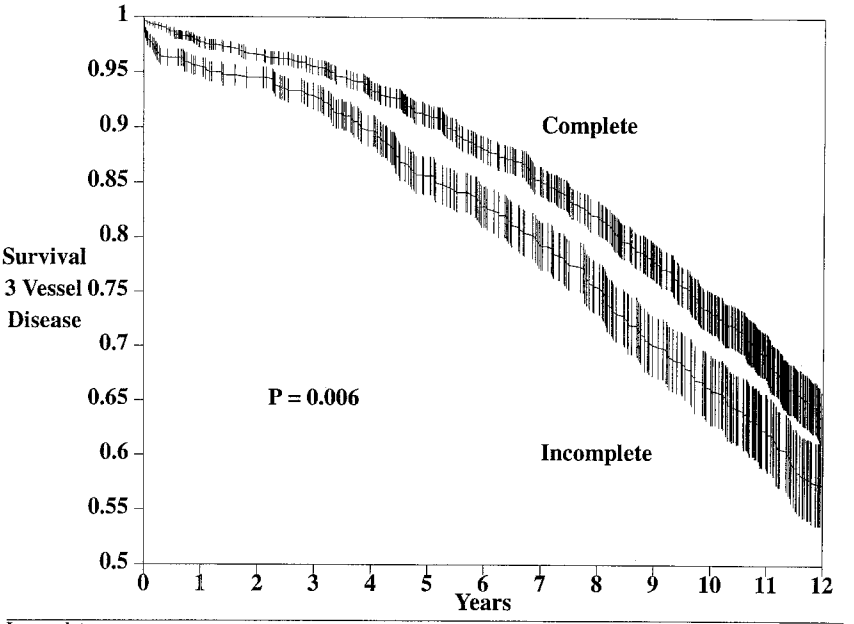
Fig. 3. Survival after complete and incomplete revascularization in patients with two-vessel disease.

correlate of long-term survival, correlating strongly with completeness of revascularization.

Univariate and multivariate analysis demonstrated that the three most important correlates of angina at follow-up were young age, presence of hypertension, and preoperative Canadian angina class 3 and 4 symptoms (Table VI). Interestingly, female gender and left ventricular dysfunction were associated with more angina at follow-up, but to a lesser extent than age, hypertension, or preoperative angina class. Diabetes was also predictive of angina at follow-up. Completeness of revascularization and increased number of vessels diseased were univariate correlates only.

Fig. 1 displays overall survival in patients with complete and incomplete revascularization. Survival is higher in patients with complete revascularization, and the separation between the curves is greater at 8 years than at 4 years. By 12 years the curves start to come together. A similar set of curves (Fig. 2) shows survival in patients with ejection fractions greater than 50%. Survival is higher overall, and again survival is better in patients with complete revascularization. Survival curves for patients with two-vessel disease are displayed in Fig. 3. Again, improved survival in patients with complete revascularization is noted. Similar results may be noted for patients with three-vessel disease (Fig. 4). The data in patients with incomplete revascularization were examined in more detail. The data for patients with the incompletely revascularized zone in the circumflex distribution, right coronary distribution, left anterior descending distribution, and multiple zones are displayed in Fig. 5. The best survival was noted if the circumflex was the nonrevascularized zone. The worst survival was in patients with the left anterior descending not revascularized or with multiple zones not revascularized. Fortunately, there were few patients in these categories (41 and 55, respectively).

Freedom from myocardial infarction is displayed in Fig. 6. There was a trend toward fewer myocardial infarctions in the completely revascularized group. Freedom from additional revascularization, either by repeat coronary operation or coronary angioplasty, is displayed in Figs. 7 and 8, respectively. There was no difference between the groups noted.



Incomplete													
N Remaining	587	555	544	527	501	469	446	423	400	369	346	295	254
Survival	1	0.956	0.945	0.928	0.897	0.856	0.828	0.792	0.755	0.701	0.663	0.621	0.572
Deaths	0	26	32	42	59	82	97	116	136	164	184	205	228
Complete													
N Remaining	1068	1020	1002	982	952	916	873	832	798	749	695	612	515
Survival	1	0.977	0.966	0.955	0.934	0.911	0.88	0.851	0.82	0.779	0.733	0.691	0.634
Deaths	0	24	36	47	69	92	123	151	181	221	265	304	352

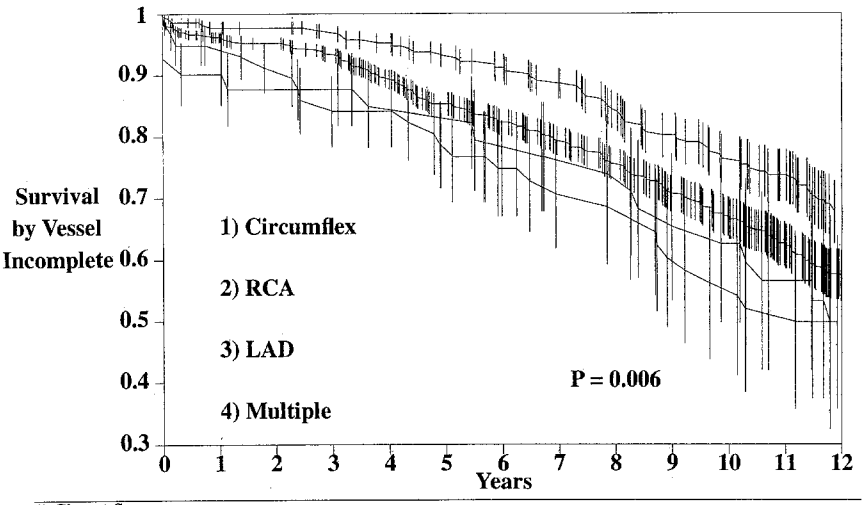
Fig. 4. Survival after complete and incomplete revascularization in patients with three-vessel disease.

Discussion

This study has confirmed the importance of completeness of revascularization, independent of overall left ventricular function and number of vessels diseased, on survival after coronary bypass operation. The deleterious consequences of incomplete revascularization were most pronounced in patients who did not receive revascularization in the left anterior descending zone or in multiple vascular zones. At least in this series, incomplete revascularization of the left anterior descending artery or of multiple zones was relatively infrequent. There was a trend toward fewer myocardial infarctions at follow-up in the complete revascularization group and a univariate association of complete revascularization with less angina. Completeness of revascularization was not shown to predict need for additional revascularization procedures. It should be noted that surgical technique has improved since the time of this study with better myocardial protection and routine use of the internal thoracic artery.[3] Thus better long-term results might be expected for similar patients given current surgical practice.

Regardless of the mode of intervention (operation or angioplasty), the ultimate value of completeness of revascularization has been difficult to elucidate over the years. This information becomes important when intermediate- and long-term results of both angioplasty and coronary bypass operations are evaluated. In a recent report Bell and colleagues[2] found that complete revascularization markedly enhanced long-term results in patients in the Coronary Artery Surgical Study with severe angina and left ventricular dysfunction. These results are consistent with those of several other reports in which completeness of revascularization was defined in varying ways.[4-10] The present study adds to all of these studies particularly with the nearly complete long-term follow-up. The recognition of the importance of complete revascularization has probably resulted in greater attention to this in recent years in patients undergoing coronary artery bypass operation.[11]

A recent and thorough examination of the rationale behind selection of angioplasty as the interventional treatment of choice in patients with coronary artery disease has been reported by

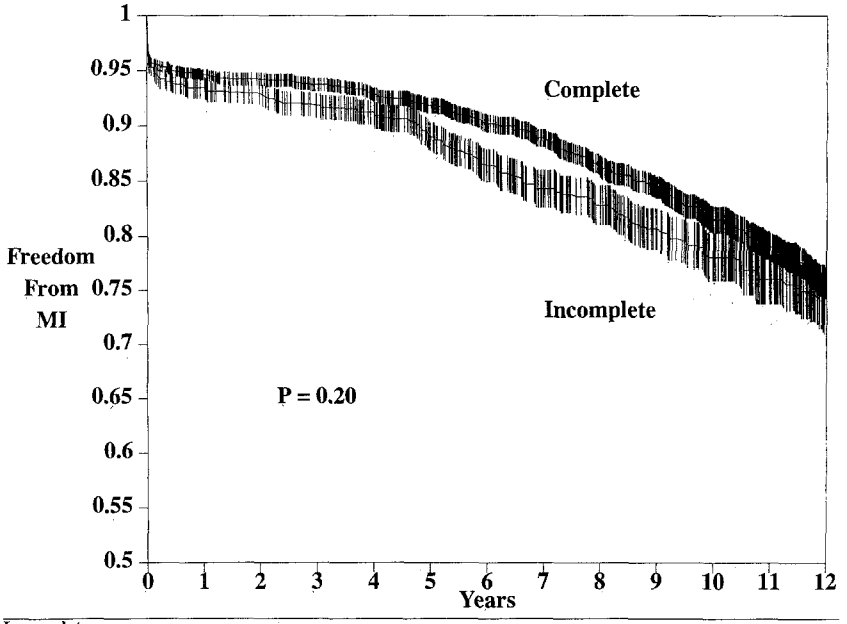


1) Circumflex													
N Remaining	215	207	204	199	193	185	180	172	162	153	144	131	108
Survival	1	0.977	0.977	0.972	0.952	0.932	0.912	0.886	0.844	0.802	0.764	0.737	0.677
Deaths	0	5	5	6	10	14	18	23	31	39	46	51	61
2) RCA													
N Remaining	505	481	472	460	430	404	385	367	347	322	302	254	220
Survival	1	0.962	0.952	0.934	0.895	0.853	0.823	0.793	0.756	0.707	0.67	0.623	0.571
Deaths	0	19	24	33	52	72	86	100	117	139	156	176	197
3) LAD													
N Remaining	41	38	35	35	32	32	30	28	27	24	23	19	15
Survival	1	0.902	0.877	0.877	0.849	0.849	0.794	0.767	0.739	0.653	0.625	0.565	0.497
Deaths	0	4	5	5	6	6	8	9	10	13	14	16	18
4) Multiple													
N Remaining	58	54	52	48	48	43	38	35	34	30	28	26	24
Survival	1	0.948	0.912	0.841	0.841	0.786	0.748	0.706	0.685	0.602	0.561	0.519	0.498
Deaths	0	3	5	9	9	12	14	16	17	21	23	25	26

Fig. 5. Survival after incomplete revascularization for patients with zone not revascularized being left anterior descending (*LAD*) distribution, circumflex, or right coronary artery (*RCA*) or with multiple coronary distributions not revascularized.

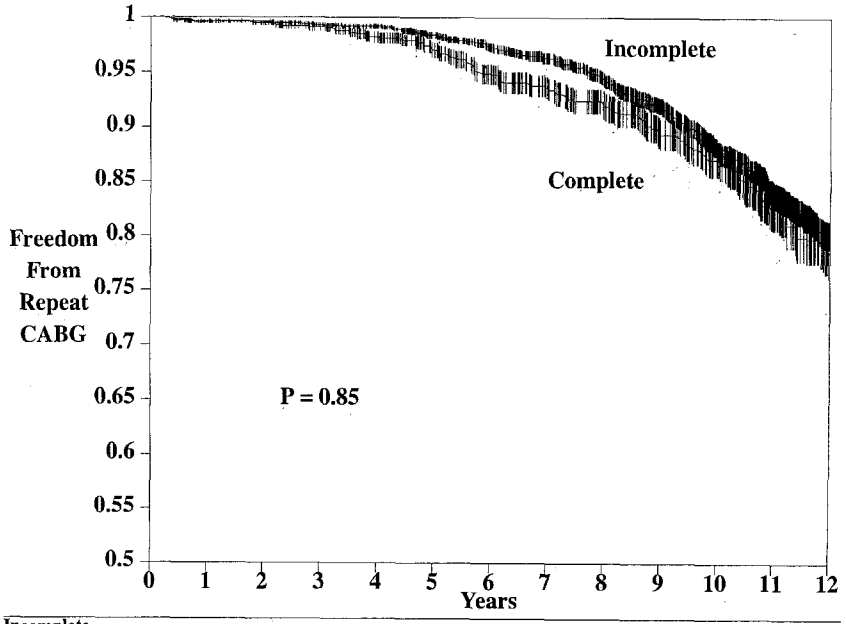
Bourassa and associates[12] from the National Heart, Lung and Blood Institute Percutaneous Transluminal Coronary Angioplasty Registry in which the strategy of complete revascularization in patients with multivessel disease was meticulously analyzed for 1942 significant lesions. Seventy-seven percent of the significant lesions were amenable to angioplasty, but it was interesting that complete revascularization was intended in only 34% of the patients. Of the entire group, complete revascularization was attempted in only 28% of patients. The reason behind these low percentages was usually either total artery occlusion or noncritical lesions at the time of angioplasty. Significant but worrisome noncritical lesions are usually bypassed at the time of a coronary bypass operation. In angioplasty, such an aggressive approach usually entails increased risk of acute closure and restenosis.

Thomas, Most, and Williams[13] and Deligonul[14] and Samson[15] and their associates have also reported on the frequency and outcome of complete revascularization in patients after angioplasty. In these series, incomplete revascularization was the outcome in two thirds of patients. Exercise stress testing 1 to 2 months after angioplasty demonstrated ischemia in 35% of the patients with incomplete revascularization and in 10% to 19% of patients with complete revascularization. In a comparison of coronary artery operation and angioplasty in patients with double-vessel disease reported by Weintraub and associates,[16] additional revascularization procedures were required at 5 years in 45% of patients who had angioplasty and in 10% of those who had coronary artery bypass ($p < 0.0001$). Complete revascularization was accomplished in 26% of patients who had angioplasty and in 92% of those who had coronary bypass operation ($p < 0.0001$) during this period. In the Emory Angioplasty/Surgery Trial (EAST),[17] a randomized comparison of coronary angioplasty and coronary operation, essentially 100% revascularization of myocardial zones requiring revascularization (index site) was achieved with operation versus 76% with angio-



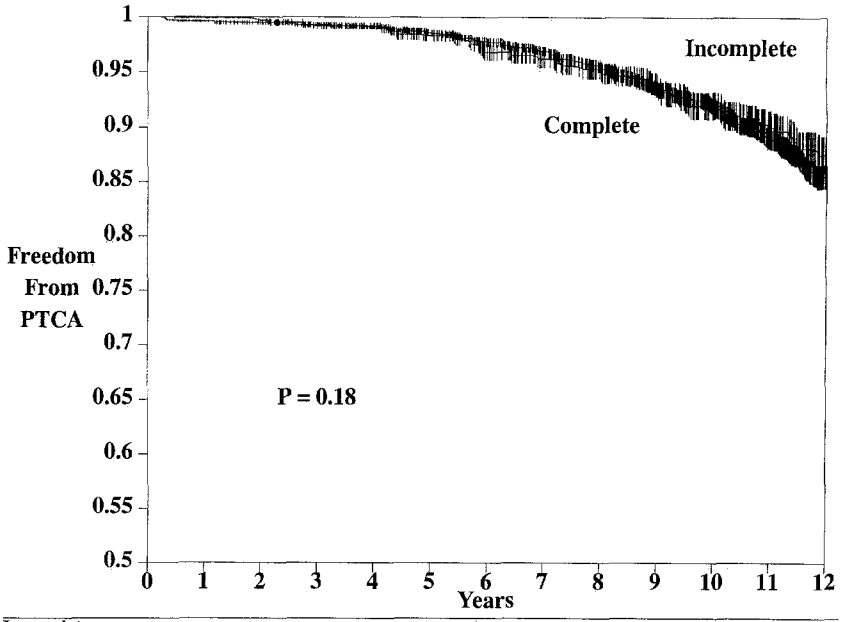
Incomplete													
N Remaining	773	706	679	653	612	561	516	475	436	388	354	292	229
FF Events	1	0.934	0.929	0.918	0.912	0.89	0.864	0.843	0.828	0.807	0.781	0.761	0.738
Events	0	51	55	63	67	81	97	109	117	128	140	148	156
Complete													
N Remaining	2003	1827	1783	1719	1648	1565	1465	1375	1286	1186	1054	895	705
FF Events	1	0.946	0.942	0.937	0.928	0.918	0.902	0.889	0.863	0.844	0.815	0.791	0.758
Events	0	108	116	125	142	159	185	206	245	272	311	341	374

Fig. 6. Freedom from myocardial infarction *(MI)* after complete and incomplete revascularization. *FF,* Freedom from.



Incomplete													
N Remaining	773	753	736	713	670	628	589	552	515	466	424	341	275
FF Events	1	0.996	0.996	0.991	0.982	0.971	0.949	0.936	0.92	0.894	0.871	0.826	0.786
Events	0	3	3	7	13	20	34	42	51	65	77	97	112
Complete													
N Remaining	2006	1929	1890	1840	1784	1704	1622	1541	1458	1355	1216	1017	803
FF Events	1	0.996	0.995	0.993	0.992	0.984	0.973	0.963	0.943	0.92	0.881	0.84	0.802
Events	0	7	10	13	16	30	48	65	96	130	186	239	280

Fig. 7. Freedom from reoperative coronary artery bypass grafting *(CABG)* after complete and incomplete revascularization. *FF,* Freedom from.



Incomplete													
N Remaining	773	755	738	713	675	633	596	561	526	481	440	367	297
FF Events	1	0.999	0.997	0.992	0.992	0.983	0.968	0.962	0.953	0.94	0.92	0.902	0.875
Events	0	1	2	6	6	12	21	25	30	37	47	55	65
Complete													
N Remaining	2004	1924	1887	1837	1780	1702	1623	1544	1465	1369	1260	1072	853
FF Events	1	0.996	0.995	0.993	0.991	0.986	0.977	0.969	0.955	0.935	0.918	0.89	0.855
Events	0	8	10	13	17	27	41	54	77	106	130	166	205

Fig. 8. Freedom from coronary angioplasty after complete and incomplete revascularization. *PTCA,* Percutaneous transluminal coronary angioplasty; *FF,* freedom from.

plasty ($p < 0.0001$). At angiographic study at 1 year, 88% of index sites revascularized surgically were patent versus 59% with angioplasty ($p < 0.0001$) and at 3 years 87% revascularized surgically were patent versus 70% with angioplasty. The improvement in the angioplasty group between 1 and 3 years reflected additional procedures in this group.

Complete revascularization was somewhat liberally defined in the present discussion because the more traditional requirement of bypassing all significantly obstructed major coronary arteries, as well as their branches, to qualify for complete revascularization was not thought likely to demonstrate a difference between the two populations of patients. It has been our opinion that supplying at least one graft to each of the three major myocardial territories would be of far greater prognostic significance.

It was surprising that a higher proportion of patients with hypertension could not be treated with complete revascularization. The reason for this was not apparent. Similarly, the presence of preoperative hypertension was found to be a strong multivariate predictor of angina at follow-up. It may be that in the future, more effective control of hypertension will improve both symptoms and long-term survival in such patients. Whether increased myocardial muscle mass, life-threatening ventricular arrhythmias, associated ascending aortic atherosclerotic disease, or other related systemic findings contribute to adverse events in these patients is not clear at the present time.

Because there is a direct correlation between the amount of viable myocardium at risk and the number and quality of arteries supplying the area, it was not unexpected that patients with better left ventricular function had a statistically greater chance of having complete revascularization. However, both the multivariate analysis and the significantly improved actuarial survival in patients with normal left ventricular function after complete revascularization demonstrated that completeness of revascularization was an independent predictor for patient survival after coronary bypass operations. Over time, there is an increasing importance of this prognostic variable.

Limitations and conclusions. The complex interactions of clinical variables, completeness of the revascularization, and type of procedure on patient outcome should be carefully considered, whatever the type of revascularization procedure proposed. That patients with complete or nearly complete revascularization have an improved prognosis after coronary operation is clear. Although it may be argued that the patients with complete revascularization were those most likely to do well, this observation remained valid for patients with normal left ventricular function. Thus in the absence of a compelling technical limitation complete or nearly complete revascularization should be attempted with coronary operation, whereas it may be of less importance with angioplasty. It is hoped that these data will contribute to the better understanding of operation for ischemic heart disease and can be used for other interventions as well.

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